A. oregonus), its anterior border becoming continuous with the anterior base of the auricle, thus forming a low rim in front of the meatus as in *A. oregonus* and *Synaptomys cooperi*. Fur everywhere long, full, and soft.

Color.—Upper parts everywhere uniform pale buffy-gray, slightly grizzled by the admixture of black-tipped hairs; under parts white, the plumbeous color of the base showing through in places on the belly; tail more or less obscurely bicolor.

Measurements of four specimens from Fort Buford, Dakota, all adults. Measurements in Millimetres.

No.	Sex.	Measured in the flesh.		Measured from the dry skin.			Date.
		Total length.	Tail to end of vertebræ.	Tail pencil.	Hind foot.	Height of ear from crown.	
38514430	♂	124	25	6.5	18.25	5.5	Sept. 8, 1887
38524431	♀	121	20	7.5		6.	" 10, "
38534432	♂	133	25	8.5	18.7	5.	" 19, "
38544433	♀	127	25	7.5	18.	5.5	" 20, "

DR. N. O. HOLST'S STUDIES IN GLACIAL GEOLOGY.

BY DR. JOSUA LINDAHL.

(Continued from July No.)

D. The moraines.—There is a marked difference between the topographical conditions of Sweden and Greenland. The latter country is all mountains. Large flat lands are nowhere to be seen, the mountains rising at once to a great altitude.[1] As a rule one

[1] A. E. Nordenskiöld: Studier och forskningar, föranledda af mina resor i höga norden, Stockholm, 1883. Pp. 63–124.

need not go very far from the coast line to reach an altitude of 1,000 feet, and peaks 3,000 to 4,000 feet high are by no means scarce. As a consequence of this topographic peculiarity the soils are here very different from those in Sweden, and particularly noticeable is the exceedingly thin layer that covers the mopentains. This is true in the same degree as the surface is more or less broken, and it is only in the narrow mountain passes that soil exists to any considerable depth. This is worth noticing in comparison with the well-known fact in Sweden that the outcrops of rock are most abundant where the land is high and broken, the explanation of which seems to be that, in a much-broken tract of ice-covered land, the lower parts of the ice must have but a slight motion, whilst its upper parts meet with but few points for their attacks.

As for the moraines of Greenland, they are essentially only ground-moraines, and inner-moraines, and, as a special form of those, one will also find border-moraines and terminal-moraines. Where the ice runs out to form ice streams, can be observed lateral moraines and, in exceptional cases, middle-moraines; these last two kinds are of minor importance.

The unmixed ground-moraine rarely comes to view, owing to its position beneath the inland-ice and under the other forms of moraines. It may, however, be observed at the side of a jökel-gate (ice-arch) or other cut in the edge of the inland ice, its characteristic features being *rounded and scratched boulders imbedded in a clayey mass of bluish color* due to the presence of iron salts of lower oxidation. It is far more common to find material from a ground-moraine mixed in among inner-moraines. Thus, at Kangarssuk and Arsuk, Dr. Holst found boulders undoubtedly belonging to a ground-moraine scattered among the more sharp-angled material of

[1] These mountains are quite often conical in shape, which has suggested the Danish name "Suckertoppen" to one of the villages of S. Greenland. The Esquimaux often apply to such mountains the name Umanak (from Umat, heart). One island with that name is located off the Arsuk fjord. It is only 600 feet in diameter, but reaches a height of 1,700 feet.

[2] The greatest altitude in Götaland (South Sweden) is found at Pustanäs in Smaland, only 1,237 feet; the highest mountain in Svealand (Central Sweden) is Städjan, 3,961 feet. The highest point in Norrland (North Sweden) is Kebnekaisse, a peak in the extreme north of the Kingdom, with an altitude of 7,194 feet.

an inner-moraine. Such occurrences become gradually more rare as one proceeds further up on the inland-ice and away from land. How the ground-moraine may occasionally form ridges on the top of the ice will be mentioned further on under the heading of *border-moraines.*

The most important moraine is the *inner-moraine.* From its location in the very mass of the ice it will gradually appear on the top as the ice melts away from its surface. It is thus generally found wherever the inland-ice borders upon land, whether this be the nunataks or the coast-lying land. Sometimes it consists of scattered stones and patches of gravel not forming a continuous covering, and then there are generally no considerable moraine deposits on the land adjacent to the ice. At other places it occurs in such abundance as completely to hide the underlying ice, giving the impression of deposits from a departed glacier rather than of a moraine still resting on the top of a glacier.

The greatest inner moraine observed by Dr. Holst was one along the southern edge of Fredrikshaab's ice-blink. It had its eastern limit close to the lake Tasek Atdlek and extended along the southern side of the ice-blink for a distance of nearly twelve miles. Its width, not far from the eastern end, was about half a mile, but the western half of it was more than a mile wide (in one place 8,300 feet), until near the western end it again became narrower. Its thickness is always greatest near land, but here it is often quite difficult to estimate its actual thickness, as it sometimes forms a compact covering, only in some fissures showing the underlying ice. This uneven thickness of the moraine-cover offers to the ice a proportionally varying protection against the sun. It thus happens that the unequal thawing moulds the underlying surface of the ice into valleys and hills, the latter sometimes rising to a height of fifty feet above the adjacent valley, and being so densely covered with moraine material that this completely hides the ice core, which, however, often forms the main part of the hill.

Farther in on the ice, the moraine gradually thins out. At the locality just referred to, the moraine-cover, 3,000 feet from land, measured several inches in depth; still the ice was seen in some bare spots. Beyond 4,000 feet from land, the moraine formed no continuous cover, and at 8,300 feet it ceased entirely, with a per-

ceptible limit against the clear ice. Only some scattered spots of sand and gravel were met with even a few hundred feet farther in on the ice. Dr. Holst estimated the average thickness of the moraine taken across its entire width near its eastern end at one to two feet. The limit between the moraine-cover and the pure ice is always located at a considerable though varying elevation above the edge of the inland-ice. In the instance of the above-mentioned moraine it varied between 200 feet and 500 feet.

The inner-moraine consists of stones, gravel and sand, mixed together. The largest blocks rarely exceed six feet in diameter, whilst by far the greatest number of them are much smaller and of a nearly uniform size. Rounded and scratched stones, derived from a ground-moraine may, in exceptional cases, be found among them, otherwise the material of the inner-moraine is characterized by its angular form, it is equivalent to the s. c. "surface-gravel," "upper boulder-gravel."

There can be but one opinion with regard to the origin of the inner-moraine. When pushing forward over higher ledges the inland-ice disintegrates the rock and carries the débris along. In its further course the ice will for some time retain nearly the same level, and the rock fragments will thus be located *in* the ice, not under it. As the ice melts away above on approaching to land this inner moraine will gradually come to the surface.

It seems proper to apply a special term for those ridge-like moraines which occur on the top of the ice, near land and parallel to it, and are met with especially in places where the land has projecting points which indent the ice; the moraines around the nunataks seem to be partially of the same character. These moraines surround the said points or the nunataks more or less in curves. Being thus confined to the borders of the inland ice they may appropriately be called *border-moraines.*

The border moraines north of the Arsuk fjord ice-river are visible far out on the sea off Ivigtut. Dr. Holst examined one that surrounds the southernmost strip of land at a distance from land of about 2,000 feet. It is not one continuous ridge but consists of several disconnected portions arranged in a semi-circle. One of these portions was about 200 feet wide and thirty-five feet high. This moraine was mainly a ground-moraine, probably forced up by some elevation of the ledge under the ice.

Another border moraine to the north of Kornok's northern ice-river, was of a different character. The stones, at least at the surface, were greatly in preponderance over the gravel. They were angular and of varying size. The moraine showed some arcuations, but taken as a whole it was parallel to the land. In some exceptional instances it approached closely to the land, even so as to touch one of the projecting points, but generally it was located some distance away from land. Its width was estimated at 100 feet, and its height at more than fifty feet; it should be remembered, however, that it might have had a core of ice. Its length was about one and a half mile. South of this moraine, and farther in on the ice, were seen three more moraines, the greatest one extending about 1,000 feet in length. Two of them were parallel, one inside the other.

Every moraine will finally be deposited in front of the glacier, and may then be called *terminal*. This term thus applied would however, be of no value. It is therefore desirable to restrict the sense of the term to such walls or osar as accumulate in front of the ice-rivers proper and generally extend across the valleys in which these rivers find their outlet. Here the moraine material gathers in such quantity and manner as to assume a character different from all other moraines. The great accumulation of material in these places does not depend on the presence of any greater quantity of such material in the ice-river than there is in the balance of the inland ice but rather on the more rapid transposition of material in these rivers.

Terminal moraines are found in front of every ice-river that does not directly run into the sea, *e.g.*, in front of Fredrikshaab's ice-blink and of the ice-rivers at Arsuk fjord and Kipissako, and of the southern ice-river at Kornok. At the last-mentioned place the terminal moraine reached a height of nearly thirty feet and surrounded the edge of the ice like the wall of a fort. At Sarkarigsok, in front of Fredrikshaab's ice-blink, were several walls, one inside the other, each about twenty feet high. The width of the total space covered by these walls aggregated about 450 feet.[3] They extended along the front of the ice-blink, both north and south, as far as the observer could see. The terminal moraines are a mixture of material derived from ground moraines and inner

moraines, sometimes mainly from the former, at other places mainly from the latter, with the addition of material from lateral moraines where such exist. Furthermore, the terminal moraines are often traversed by jökel-rivers and numerous springs which agitate and grind down the contents of the moraine. The merely local occurrence of terminal moraines and the mixed character of its contents, give to it a subordinate importance compared with the ground-moraine and the inner-moraine. Of still less importance are the lateral moraines and the middle-moraines. Of the latter kind none were observed by Dr. Holst. Lateral moraines are met with along the sides of the ice-rivers and at the foot of the nunataks. In the moraines are found some rocks not derived from the neighboring mountains. For this and other reasons, it seems evident that the lateral moraines are not altogether made up of débris from the adjacent sides of the mountains, but have received contributions from inner-moraines, and, in some instances, also from the ground moraine.

Dr. Holst calls particular attention to the fact that in Greenland the blue and the yellow clays are formed simultaneously by the action of the same inland-ice, the former near its bottom where it is protected from the oxidizing influence of the air, the latter nearer its surface; and he regards the bearing of this observation as an argument against the theory, according to which the lower blue clay and the upper yellow clay in Sweden, Denmark, and Germany, are supposed to owe their formation to two different glacial periods.

E. *The upper-drift deposits* are invariably found in process of formation in the larger valleys in front of the ice-rivers, or, in other words, along the greater jökel-rivers. Here they form more or less level plains, through which the river cuts its channel. Equal deposits are also met with in tracts from which the ice has departed, and here too their occurrence is confined mainly to the larger valleys in which once terminated greater or smaller ice rivers with jökel rivers issuing from them. The moraines from which the upper drift derives its material are partially the inner, partially the ground moraine, which first combine to form the

[1] An abundance of Diatoms flourishes in the waters between the terminal moraine and the inland-ice. In one place, at Sarkarigsok, this vegetation displayed a brilliant yellow color.

terminal moraine in front of the ice-rivers, and the material is gradually worked over by the jökel-rivers.

The force of the jökel-rivers is greatest nearest the inland-ice and diminishes as they approach the sea. In consequence, the greatest stones are found near the terminal moraine, whilst further on their size is reduced more and more until all is sand, spreading out to wide sand-plains, as is the case, for instance, off Fredrikshaab's ice-blink. The finest impalpable material is carried out into the fjords and open sea, where it forms deposits of clay.

The upper drift of Greenland shows a considerable resemblance to that of Sweden. Both are free from boulders. The gravel is assorted and stratified. The stones are well ground, although more rounded in Sweden than in Greenland. These deposits in the latter country are not unfrequently of a considerable thickness. In the bottom of the Tasiussak fjord and in a few other places they measured about 100 feet.

There are, however, no typical osar in the part of Greenland visited by Dr. Holst, who found only some smaller hills to a faint degree resembling those formations. There can be no doubt that the osar are formed near and in close relation to an inland-ice. Nothing but such ice could have transported these masses to their present locations, and nothing but the enormous force of the torrents rushing from the ice could have wrought the material so thoroughly. Still it may be less certain that the ose form has been caused in Greenland by the same agencies as those that produced glacial osar in Sweden. It may be a mere accidental resemblance and the form may depend on later excavations. Such osar were formed within the time of the melting of the inland-ice. The coast-land of Greenland presents the same character as Sweden so far that it has formerly been covered with inland-ice which has long ago melted away. Why then is it that typical osar do not exist in the said district of Greenland? Dr. Holst finds the answer to this question in the topographical differences of the two countries. He refers to his earlier discussion of the formation of the glacial osar in Sweden, a summary of which discussion was given at the beginning of this article. As stated there, such osar are formed as sediment in the beds of rivers, having cut their channels into the surface of an inland-ice. The requisite conditions for the formation of large osar

are, among others, first, that the water-divides on the inland-ice shall be sufficiently far apart so that the water supply may be sufficiently great to form larger rivers, and, secondly, that the ice shall be sufficiently free from crevasses, which would otherwise drain off the water beneath the ice instead of on its surface.

It is then evident that, in Sweden, the broad valleys and lowlands with gently rising sides must have offered particularly favorable conditions for the formation of vast gravel-osar, whilst such osar can occur only as local formations of smaller dimensions in the mountain regions of the country. It has long been supposed that gravel-osar were entirely absent from Norway. This is, however, not altogether true, but they are of rare occurrence, which fact fully agrees with the above theory. On the plains of the extreme south of Sweden, as also of Denmark and Germany, the absence of large drainage basins has hindered the formation of greater osar, although they are not altogether absent from Skane, and equivalent formations have been observed by Dr. Holst at Neustadt-Eberswalde. It is equally evident, that the topographical conditions in those parts of southern Greenland above described (page 705) do not admit of any formation of larger osar. In a country so broken and mountainous, the inland ice must be full of cracks, preventing the water from gathering to any great extent over its surface. Such cracks do not necessarily exist in a moving inland ice, and Dr. Holst mentions a smaller tract of ice between Tasek Atdlek and Kangarassuk, which was entirely free from cracks, and, as a consequence, was covered with water, which gathered into a channel five feet wide and five feet deep, in one place separating into two branches, enclosing an island of ice, before it finally rushed into a jökel-well. Also Nordenskiöld and the Danish explorers of the inland-ice met with water flooding its surface.

If the above-given reasons for the absence of gravel-osar from the mountainous part of Greenland are correct, there could have been nothing to prevent such osar from forming in the less broken tracts, f. i. the district of Holsteinborg. Dr. Holst found no opportunity of visiting that district, but after returning home he learnt from A. Kornerup's report of his travels in 1879 (published in 1881) that he had found in the Arsalik valley, N. E. of Holsteinborg, a typical gravel-ose about four miles long, parallel to the

present direction of the motion of the inland-ice, and having a roof-shaped top, and even sides, inclined 20° to 25° to the plane of the valley over which it extended in a meandering course. Mr. Kornerup also states, that the said valley is "an unusually large plain, bounded by even, gently-sloping foothills."

This observation thus fully corroborates Dr. Holst's theory.

EDITORS' TABLE.

EDITORS: E. D. COPE AND J. S. KINGSLEY.

For several years past the Peabody Museum of Archæology and Ethnology, at Cambridge, Mass., has been engaged in the exploration of the remains of the mound builders. More lately, under the direction of the Curator Professor, F. W. Putnam, it has confined its labors to the mounds of Ohio, and especially to those of the Little Miami Valley. A most careful and thorough method of work has been adopted, which has resulted in each mound investigated telling all that it could tell. Some time ago Professor Putnam informed the Bureau of Ethnology of the nature of his work, and requested that they leave him his chosen field, the Little Miami Valley, for his own exploration. This was, of course, an eminently reasonable request. He was first in that field, and had devised his methods of research, while there were thousands of other mounds which were open to other investigators. Besides, in order that the mounds may reveal as much as possible, it is necessary that all in a certain region be investigated by the same hand. With a striking disregard of scientific courtesy the Bureau of Ethnology has this year sent a party into the Little Miami Valley, thus encroaching upon the very territory which was already being explored, and explored—if the testimony of unprejudiced witnesses can be relied upon—in a more thorough manner than is the case with the rapid work of the party under the charge of Professor Cyrus Thomas. Government money should be put to a better use than this.